

What is claimed is:

1 1. A method, using a computer, for performing defect analysis on a
2 plurality of images from an inspection system, comprising:
3 storing said plurality of images in a computer readable medium;
4 retrieving an inspection image from a first image of a stored plurality of
5 images;
6 retrieving a corresponding reference image from a second image of said
7 stored plurality of images; and
8 analyzing said inspection image and said corresponding reference image to
9 determine if a defect exists.

1 2. The method of claim 1 wherein said first image and said second
2 image are a same image.

1 3. The method of claim 1 wherein said stored plurality of images are
2 clipped images.

1 4. The method of claim 1 wherein said analyzing includes displaying
2 said inspection image.

1 5. The method of claim 1 wherein said analyzing occurs during actual
2 inspection.

1 6. The method of claim 1 wherein said analyzing occurs in after-
2 inspection follow-on analysis.

1 7. The method of claim 1 wherein said plurality of images are images
2 from die to die comparisons, array comparisons, or both.

1 8. A method, using a computer, for inspecting for defects in a circuit
2 pattern, comprising:
3 determining if there is a defect candidate image, by thresholding a
4 difference image, wherein said difference image comprises a difference between an
5 inspection image and a corresponding reference image;

if there is said defect candidate image, storing a clipped inspection image in a computer readable medium, wherein said clipped inspection image is a portion of said inspection image; and

if there is said defect candidate image, storing a corresponding clipped reference image in said computer readable medium, wherein said corresponding clipped reference image is a portion of said corresponding reference image.

9. The method of claim 8 further comprising storing a clipped defect candidate image, when there is said defect candidate image.

10. The method of 8 further comprising, when there is said defect candidate image, storing defect information, comprising defect candidate positional coordinates, in said computer readable medium.

11. The method of 8 further comprising, when there is said defect candidate image, determining a margin.

12. The method of claim 8 further comprising:
using said clipped inspection image and said clipped reference image to determine a margin; and
storing said margin in said computer readable medium.

13. The method of claim 8 further comprising:
determining a classification, a threshold for a type of defect, or an enhanced result based in part on said clipped inspection image and said clipped reference image.

14. The method of claim 13 wherein said determining further uses defect information.

15. An inspection system for examining a plurality of images showing potential defects in a circuit pattern on a semiconductor material, comprising:
a defect image memory for storing clipped images of said plurality of images;

an image analyzer, comprising a plurality of processors, coupled with said defect image memory, for analyzing said clipped images retrieved from said defect image memory; and
a non-volatile storage coupled with said image analyzer for storing said clipped images and results of said analyzing.

16. The inspection system of claim 15 wherein said results are defect detection margins.

17. The inspection system of claim 15 wherein non-volatile storage further stores defect information.

18. The inspection system of claim 15 wherein said plurality of images comprise an inspection image and a corresponding reference image.

19. A method for detecting defects in a circuit pattern on a semiconductor material using an inspection system comprising:
storing a plurality of scanned images from a detecting apparatus;
determining an inspection image and a reference image from said plurality of scanned images based on a selection of either die to die comparison or array comparison; and
using said inspection image and said reference image, determining a defect candidate image.

20. The method of claim 19 further comprising:
when then there is said defect candidate image, clipping a first area from said inspection image and a corresponding second area from said reference image.

21. The method of claim 20 further comprising:
sending a first clipped image, comprising said first area, for storage in a defect image memory.

22. The method of claim 19 wherein said selection is different for different areas of a wafer.

1 23. An image processing system for detecting defects in a circuit
2 pattern on a semiconductor material using images from a detecting apparatus, said image
3 processing system comprising:

4 an image memory for storing said images; and
5 a defect detection image processing module for detecting defect candidate
6 information from stored images, wherein at least one of said stored images includes an
7 inspection image.

1 24 The image processing system of claim 23 wherein said at least one
2 of said stored images further includes a related reference image.

1 25 The image processing system of claim 23 wherein said defect
2 candidate information, comprising defect candidate positional information, is used by said
3 defect detection image processing module to clip said inspection image and said related
4 reference image.

1 26. The image processing system of claim 23 further comprising an
2 overall control for determining when die to die comparison or array comparison is used
3 on said inspection image and said related reference image.

1 27. A method using a computer for determining an updated threshold
2 for use in actual inspection of a semiconductor wafer, said method comprising:
3 setting an initial threshold;
4 determining a plurality of difference metrics using said initial threshold;
5 determining a difference distribution based on said plurality of difference
6 metrics; and
7 determining said updated threshold based on an evaluation of said
8 difference distribution.

1 28. The method of claim 27 wherein a difference metric of said
2 plurality of difference metrics comprises thresholding a difference between a clipped
3 inspection image and a clipped reference image.

1 29. The method of claim 27 wherein a difference metric of said
2 plurality of difference metrics comprises a margin.

1 30. The method of claim 27 wherein a difference metric of said
2 plurality of difference metrics comprises a signal amplitude difference between a
3 maximum signal value of a cross-section of a difference image and said initial threshold,
4 said difference image comprising subtracting a clipped reference image from a clipped
5 inspection image.

1 31. The method of claim 27 wherein said evaluation of said difference
2 distribution comprises, finding a minimum in the difference distribution.

1 32. The method of claim 27 wherein said evaluation of said difference
2 distribution comprises finding a stabilized area under said difference distribution.

1 33. The method of claim 27 wherein said evaluation of said difference
2 distribution comprises using a fixed value for a defect count or defect density.

1 34. A method of resetting a threshold using a display coupled with a
2 computer, said method comprising:
3 displaying a first threshold value on said display, said first threshold value
4 used to select defect candidate image indications to be shown on a defect candidate
5 distribution screen of said display;
6 changing said first threshold value to a second threshold value, wherein
7 said defect candidate image indications on said defect distribution screen change
8 responsive to said second threshold value.

1 35 The method of claim 34 further comprising:
2 selecting a selected indication of said defect candidate image indications;
3 and viewing an inspection image associated with said selected indication.

1 36 The method of claim 34 wherein said first threshold is calculated
2 using an electron beam noise value for a SEM system.

1 37. A method in a computer system for determining a threshold for use
2 in actual inspection of a semi-conductor material, comprising a circuit pattern, said
3 method comprising:
4 displaying a first threshold and a second threshold;

displaying a graphic representation of a defect candidate image with a margin greater than or equal to said second threshold minus said first threshold; when said graphic representation of said defect candidate image is selected for expanded viewing, displaying a clipped image associated with said graphic representation; and when said defect candidate image is a false defect, and a predetermined number of allowable false defects is exceeded, receiving a new second threshold.

38. The method of claim 37 wherein said clipped image is selected from a group consisting of a clipped inspection image, a clipped reference image, or a clipped defect candidate image.

39. A method in a computer system for displaying a defect candidate, said defect candidate stored in a memory, said method comprising: displaying a two-dimensional defect candidate distribution for a threshold on a first screen, said two-dimensional defect candidate distribution comprising an indication of said defect candidate; and displaying on a second screen an expanded view of said defect candidate, responsive to a selection of said indication on said first screen.

40. The method of claim 39 wherein said expanded view comprises an image associated with said defect candidate and selected from a group consisting of a clipped inspection image, a clipped reference image, or a defect candidate image.

41. The method of claim 39 wherein said expanded view comprises a re-scanned image of said defect candidate.

42. The method of claim 39 further comprising a threshold screen for changing said threshold.

43. The method of claim 39 further comprising a screen displaying a graph of defect density versus threshold.

44. The method of claim 39 wherein said two-dimensional defect candidate distribution displays defect candidates responsive to a user selected area.

1 45. The method of claim 39 wherein said two-dimensional defect
2 candidate distribution displays defect candidates by type of defect.

1 46. The method of claim 45 wherein each type of defect has a different
2 symbol, said defect being displayed using a symbol.

1 47. The method of claim 45 wherein each type of defect has an
2 associated threshold value.

1 48. The method of claim 39 wherein said two-dimensional defect
2 candidate distribution displays defect candidates as symbols.

1 49. The method of claim 48 wherein a symbol of said symbols
2 comprise a grayscale value.

1 50. The method of claim 49 wherein said grayscale value is related to a
2 margin.

1 51. The method of claim 49 wherein said grayscale value is related to
2 an enhanced result.

1 52. The method of claim 48 wherein a symbol of said symbols
2 comprise a color value.

1 53. The method of claim 48 wherein a symbol of said symbols
2 comprise a black or a white value.

1 54. A system for displaying a symbol associated with a defect
2 candidate of said plurality of defect candidates, comprising:
3 a computer readable medium for storing images associated with said
4 plurality of defect candidates, wherein said images comprise an inspection image and a
5 reference image associated with said defect candidate;
6 a processor coupled with said computer readable medium for determining
7 a margin associated with said defect candidate, said margin calculated using said
8 inspection image and said reference image; and

9 a display for displaying said symbol when said margin is equal to or above
10 a threshold difference.

1 55. The system of claim 54 wherein said threshold difference is a
2 difference between a display threshold value and a predetermined initial threshold value.

1 56. A distributed system for inspecting semiconductor circuit pattern
2 defects, comprising:

3 an inspection apparatus for acquiring a plurality of images associated with
4 said semiconductor circuit pattern defects and for performing defect analysis on a
5 plurality of stored images;

6 a server connected to said inspection apparatus via a communications
7 network for storing said plurality of images, and for providing access to said plurality of
8 stored images; and

9 a client computer connected to said server and said inspection apparatus
10 via said communications network for displaying a plurality of symbols associated with
11 selected images of said plurality of stored images in response to selection of said selected
12 images by said defect analysis.

1 57. The distributed system of claim 56 wherein said communications
2 network comprises an Internet.

1 58. The distributed system of claim 56 wherein said communications
2 network comprises a Local Area Network.

1 59. The distributed system of claim 56 wherein said client computer
2 further displays an image of said selected images in response to a user selection of an
3 associated symbol of said plurality of symbols.

1 60. The distributed system of claim 56 wherein said defect analysis
2 comprises calculation of a margin.

1 61. The distributed system of claim 56 wherein said defect analysis
2 comprises threshold recalculation.

62. A distributed system for inspecting semiconductor circuit pattern defects, comprising:

- an inspection apparatus for acquiring a plurality of images associated with said semiconductor circuit pattern;
- a server coupled with said inspection apparatus via a communications network, said server operably disposed for:
 - storing said plurality of images;
 - performing defect analysis on a plurality of stored images; and
 - providing access to said plurality of stored images; and
- a client computer coupled with said server via said communications network for displaying a plurality of symbols associated with selected images of said plurality of stored images in response to selection of said selected images by said defect analysis.

63. A method for determining an inspection threshold used in actual defect inspection of a semiconductor, said method comprising:

- calculating a first threshold using a defect difference distribution;
- storing a second threshold based on said first threshold in a computer readable medium; and
- using said second threshold in actual defect inspection.

64. The method claim 63 wherein said computer readable medium includes a recipe comprising said second threshold.

65. The method claim 63 wherein said first threshold is greater than a predetermined initial threshold.

66. A method for determining a selected threshold of a plurality of thresholds, said plurality of thresholds for use in actual defect inspection of a semiconductor, said method comprising:

- determining said plurality of thresholds from a defect difference distribution;
- displaying to a user an indication for each of said plurality of thresholds;
- and

responsive to said user selection of a selected threshold of said plurality of thresholds, displaying symbols of defects with differences greater than or equal to said selected threshold.

67. The method of claim 66 wherein said determining said plurality of thresholds is based on one or more local minimums in said defect difference distribution.

68. A system for determining a first threshold for use in actual inspection of circuit pattern defects in a semiconductor material, said system comprising:
a defect detection unit for determining defects with differences above a second threshold minus a predetermined value; and
a display having an input mechanism for adjusting said first threshold, wherein said first threshold has an initial value of said second threshold.

69. The method of claim 68 wherein said second threshold is related to a defect difference distribution.

70. An image processing system for determining a new threshold for use in inspection of a circuit pattern on a semiconductor material, comprising:
a defect detection unit for determining a plurality of defect sets, wherein a defect set of said plurality of defect sets comprises an inspection image and a reference image with a difference above a predetermined threshold ; and
an image analysis unit for using said plurality of defect sets to determine a difference distribution and for using said difference distribution to determine said new threshold.

71. The image processing system of claim 70 wherein at least one image in said defect set is a clipped image.

72. The image processing system of claim 70 further comprising a defect image memory for storing said defect set.

73. The image processing system of claim 70 further comprising an image memory comprising said reference image and said inspection image.

74. The image processing system of claim 70 further comprising a storage medium for storing said defect set.

75. A method for inspecting a specimen, comprising:

2 setting a threshold value;
 3 detecting a detected image of a specimen;
 4 comparing the detected image to a reference image;
 5 extracting from the comparing, a defect candidate using the threshold
 6 value;
 7 storing an information of the defect candidate to a memory;
 8 setting a new threshold value; and
 9 extracting a defect from the defect candidate using the stored information
 10 and the new threshold value .

1 76. A method of inspecting a specimen according to claim 75, wherein
 2 the information of the defect candidate stored in the memory includes at least one of the
 3 following: a defect candidate position, a defect candidate area, a defect candidate x and y
 4 projection size, a maximum difference between the detected image and the reference
 5 image, a defect texture, or a reference texture.

1 77. A method of inspecting a specimen according to claim 75, wherein
 2 the information of the defect candidate stored in the memory includes an image of the
 3 defect candidate.

1 78. The method of claim 75 wherein the specimen includes a circuit
 2 pattern on a semiconductor wafer.

1 79. A method for inspecting a circuit pattern on a semiconductor
 2 material comprising:
 3 setting an initial threshold;
 4 detecting an inspection image;
 5 determining defect candidate information by thresholding a comparison
 6 between said inspection image and a reference image, wherein said thresholding uses said
 7 initial threshold;
 8 determining a new threshold using said defect candidate information; and
 9 evaluating a defect in said inspection image using said new threshold.

1 80. The method of claim 79 wherein said defect candidate information
 2 includes a margin.

1 81. A computer program product stored on a computer readable
2 medium for inspecting a specimen, comprising:
3 code for setting a threshold value;
4 code for detecting a detected image of a specimen;
5 code for comparing the detected image to a reference image;
6 code for extracting from the comparing, a defect candidate using the
7 threshold value;
8 code for storing an information of the defect candidate to a memory;
9 code for setting a new threshold value; and
10 code for extracting a defect from the defect candidate using the stored
11 information and the new threshold value.

1 82. A computer program product stored on a computer readable
2 medium for inspecting a circuit pattern on a semiconductor material comprising:
3 code for setting an initial threshold;
4 code for detecting an inspection image;
5 code for determining defect candidate information by thresholding a
6 comparison between said inspection image and a reference image, wherein said
7 thresholding uses said initial threshold;
8 code for determining a new threshold using said defect candidate
9 information; and
10 code for evaluating a defect in said inspection image using said new
11 threshold.